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IN THIS ISSUE

Accounting for By-Products and Joint Products, by Howard C. Greer 1399

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EDITORIAL DEPARTMENT NOTE

The apportioning of material costs and processing costs to a group of joint products or to a main product and one or more by-products has always been one of the more difficult problems of cost accounting. In a sense there is no one correct or final solution to a problem of joint product or by-product costing, because in the final analysis any method used must be arbitrary. The problem, then, is largely one of selecting the method of apportioning costs which best meets the needs of the particular concern and industry, and which results in the most nearly correct statement of the financial facts involved. A knowledge of the various methods available and an understanding of how these methods are applied in particular industries is of considerable help in attacking such a problem. For this reason we are pleased to offer our readers in this issue of the Bulletin a most comprehensive discussion of the problem of joint and by-product accounting, together with several illustrations of methods used in practice.

Howard C. Greer, the author of this article, is especially well qualified to write on this subject, having been associated for the last nine years with the Institute of American Meat Packers as Director of the Department of Accounting and Marketing. Joint and by-product costs are most important in the packing industry. Prior to accepting his present position, Mr. Greer spent several years in industrial and public accounting work and served as Chairman of the Department of Accounting and Director of the Bureau of Business Research at Ohio State University. He is a graduate of Northwestern University, a C. P. A. of Illinois and Ohio, and at the present time, in addition to his duties with the Institute of American Meat Packers, is Professor of Accounting at the University of Chicago. Mr. Greer is the author of a number of books and articles on accounting subjects.

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ACCOUNTING FOR BY-PRODUCTS AND JOINT PRODUCTS

By Howard C. Greer, Director of Accounting,
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THE problem of joint costs is met in almost every industry. It is one of the most difficult problems with which the cost accountant has to deal.[1] By nature it permits of no perfect theoretical solution. It does call for accounting treatment which shall be reasonable and well adapted to the needs of the enterprise concerned.

There are two major divisions of the problem: (1) allocation of the cost of joint services rendered in connection with a group of manufacturing processes, usually known as overhead cost accounting; (2) allocation of the cost of a single basic raw material or group of materials among a number of joint products, usually known as by-product or joint-product cost accounting. The latter subject is discussed in this paper.

Where a single price is paid for a group of joint services, or for the combination of utilities existing in a single raw material it is not possible to say with finality that any given fraction of that price pertains to any one of the services or utilities considered separately. The cost incurred may be allocated among the joint services or products on some arbitrary basis. The cost accountant's problem is to determine the most satisfactory basis.

One method is to attempt to determine what each one of the various services would have cost if it had been purchased independently. If the independent cost of each of the services or utilities can be thus determined the single joint cost actually incurred may be apportioned accordingly. Where independent costs of the individual items are not determinable it sometimes is possible to arrive at such costs by inference. When various combinations of the services or utilities are available some statistical method may be utilized to develop the implied cost of the missing elements and thus to build up a complete set of assumed individual cost figures.

The other method commonly employed is to make an apportionment based on the net realizable values of the various services or

[1] For an extended discussion of the theoretical aspects of this problem see Clark, *Economics of Overhead Costs* (University of Chicago Press).

products obtained from the process by which they are jointly produced. If there is a single major product and one or more by-products, the values of the by-products may be deducted from the total cost and the remainder may be treated as the cost of the major product. Where a number of joint products result, the total cost of the raw materials (sometimes including the cost of processing as well) may be apportioned among the joint products according to their relative net realizable values, as found by subtracting from their selling prices the costs that remain to be incurred in processing and distributing them.

The first of these two methods is commonly used in the apportionment of joint service costs such as factory overhead. The second is most commonly used in accounting for by-products and joint products.

Importance of By-Products and Joint Products in Industry

By-products and joint products are found in a great variety of industries Often they are items of minor importance, such as scrap and spoiled product, and are given little accounting recognition. There are many industries, however, in which by-products of great importance are recovered, and some where the entire output must be considered as a group of joint products. In many of these industries the development of adequate joint cost accounting constitutes a major administrative problem.[2]

Among the industries in which by-products and joint products are of great significance may be numbered the following:

Extractive industries (metal and coal mining, petroleum oil extraction and refining, logging and lumbering, etc.)

Agricultural product industries (meat packing, dairying, canning, milling, sugar refining, cotton ginning, cottonseed crushing, etc.)

Chemical process industries (manufacture of dyes, solvents, preservatives, fertilizers, explosives, etc.)

The biennial Census of Manufactures indicates that these industries account for approximately 50% of the total value of all manu-

[2] For a comprehensive discussion of the managerial problems involved in proper accounting for by-products and joint products see Bliss, *Management Through Accounts*, Chapters XXXIII-XXXVI (Ronald Press).

factures produced in the United States. By number, however, they represent only about 15% of all industries. It is probably due to their being in the minority numerically that their accounting methods have been discussed rather infrequently in cost accounting literature.

As indicated in the foregoing, by-product and joint-product costs ordinarily are apportioned according to the relative values of the products recovered. This procedure sounds simpler than it is. Values are of various kinds, and the accountant must determine which kind of values will be most useful for this purpose. For example, he may consider as values (a) amounts actually realizable under current market conditions, (b) amounts estimated to be recoverable at some future time, (c) amounts "normally" recoverable, as determined from past experience, (d) arbitrary or nominal amounts. Current market values are most commonly used, though in some industries the cost apportionment is based on what are considered normal value relationships, and in a few instances on purely nominal or arbitrary values.

Three Methods Outlined

The set of values selected as furnishing a satisfactory comparison may be used in one of the following ways:

Method 1. If the process results in a single major product and one or more by-products, a net cost for the major product may be determined by deducting from the total cost the values assignable to the by-products. The by-product values may be either the *gross* returns which will be obtained from sale of the by-products (in which case all costs of processing and distribution are charged against the major product), or they may be estimated *net* recoverable values after allowance for by-product expenses, in which case the charges against the major product will consist only of the cost of the raw material plus the processing and distribution expenses assignable to the major product.

Method 2. If the process results in a number of joint products and no single major product, the total cost of the raw materials plus processing expenses may be allocated to the several products in proportion to their relative values. The costs will be treated jointly, at least up to the point where the various products are sep-

arated; after the separation the ensuing charges may be applied individually to the several products.

Method 3. If circumstances make it impractical to allocate the aggregate cost to the various products according to their relative values, it may be equally satisfactory under some conditions to substitute for costs the computed net recoverable values of the various products at the point of separation. This procedure is employed in certain cases where the joint products change rapidly in form and amount, where profit margins are narrow and turnover rapid, and where selling prices are constantly fluctuating.

Effect of Each Method on the Income Statement

It is evident that each of the three methods described above will produce a different type of income statement. Under Method 1, for example, the profit from operations (theoretically) will be reflected solely in the accounting for the major product, since the by-products have been credited to the major product cost at their estimated net selling value. Under Method 2 the net income will be distributed among the various joint products in proportion to their relative selling values, which is to say that the income statement will show the same percentage of profit for each product. Under Method 3 profits or losses are taken up from time to time during the processing, instead of being reflected only when the products are finally sold; this is an important departure from ordinary accounting practice, but one which may be justified under certain circumstances.

As it actually works out, accounts kept under any of these methods do not always show exactly the net income figure which might be expected on the basis of the accounting methods employed. This is because the values assigned during the process of accounting for the by-products and joint products are not always the values finally recovered when the products are sold.

In the case of by-product accounting, for example, the credit to the cost of the major product is made on the basis of an estimate, which may include the following factors: (a) the quantity of each by-product which will be finally recovered; (b) the expense which will be incurred in recovering the finished by-product, and in delivering and selling it; (c) the market price at which the

sale will be made. The estimate is subject to error or change in respect to all three of these factors. In consequence, the account for each by-product, instead of balancing exactly, is likely to show a small profit or loss, representing the variance between actual and estimated results on that by-product after it has been separated from the major product.

Similarly, under Method 2, the relative values finally obtained for various joint products may not be in exact proportion to those which were assumed as normal at the time the cost allocation was made. The values used may be current selling prices, or normal selling prices, or some arbitrary set of prices believed to bear a proper relationship to one another. Whichever values are used, the conditions may change before the sale takes place, and the gross and net margins which finally show up in the income account may be somewhat different from the estimated margins set up at the time of the joint-product cost calculation.

Classification

The application of these general principles is found not only in the large industries to which reference has been made previously, but also in certain processes in many other industries. One writer has mentioned the following cases involving by-product or joint-product accounting methods.[3]

(1) Waste—the portion of a basic raw material lost in processing, having no recovery value.

(2) Spoilage—defective portions of regular production, having a value recoverable only through re-processing.

(3) Scrap—the incidental residue from certain types of manufacture, usually of small amount and low value, recoverable without further processing.

(4) By-products—secondary products recovered in the manufacture of a major product, often of substantial value and frequently requiring independent processing after separation from the major product.

(5) Joint products—two or more products, each of major importance, separated in the course of processing, each usually requiring further individual processing after the separation has taken place.

[3] Fox: "Joint-Product Costs" (N. A. C. A. Bulletin, April 1, 1934).

The application of special accounting methods to these cases may be illustrated by examples drawn from a number of different industries. Those in the following pages do not exhaust the list of industries affected, but do illustrate the principal methods utilized.

Accounting for Waste

In accounting for waste the usual practice is simply to divide the total cost by the net quantity of product manufactured to arrive at a cost per unit. Where an attempt is made to control through the accounting records the amount of the waste-loss, the statistical data compiled should contain something to show the percentage yield in finished product, or the percentage of waste-loss, for comparison with a standard or "allowed" amount. Ordinarily, however, there is no object in assigning any money cost to the quantity lost, where it has no recovery value and the loss is an unavoidable incident of the processing operations.

Accounting for Spoilage

The problem of spoilage is met in a large group of manufacturing industries, and differs from other joint cost problems in that the matter of primary importance to the management is the *loss* due to spoilage. It is important, therefore, that the cost accounting method employed should isolate, so far as practical, the following items: (a) the accumulated cost of the spoiled product up to the point of spoilage, (b) the expense of reclamation and reconditioning, (c) the value reclaimed, if it is different from the value which would have resulted from completion of unspoiled product.

Exhibit A furnishes an example of spoilage cost calculation in a plant manufacturing drop forgings. It is assumed that the management desires to charge against each order all costs and losses incurred in connection with that order. On the job covered by the illustration a lot of 1,000 pieces was begun. The first hammer-run produced 850 usable pieces, 100 pieces which would be made usable by "re-striking," and 50 pieces completely spoiled. The second hammer-run completed 100 additional usable pieces.

The upper section of the exhibit provides for a separate record of the cost of the "re-strikes," and for the combined cost of the

EXAMPLE OF SPOILAGE COST CALCULATION IN DROP FORGE PLANT

Order 177 Date 3/5/36 Pattern B-19 No. Begun 1,000 No. Finished 950

Item	*Unit*	*Unit Cost*	*Base Run Units*	*Base Run Total*	*Restrikes Units*	*Restrikes Total*	*Combined Units*	*Combined Total*
Material	Pc.	.18	1,000	$180.00	...	....	1,000	$180.00
Labor	Pc.	.26	1,000	260.00	100	$26.00	1,100	286.00
Hammer time	Hr.	$ 3.00	50	150.00	5	15.00	55	165.00
Set-up	Flat	$22.00	....	22.00	...	....	....	22.00
Totals				$612.00		$41.00		$653.00
Cost per piece begun		.612			.041		.653	

Cost of Defective Work	*Total*	*Per Pc. Fin.*
Restrikes (as above)	$41.00	.043
Spoiled:		
50 pcs. @ .612 ea.		
Salvage @ .080 ea.		
Net cost .532 ea.	26.60	.028
Total cost def. work	$67.60	.071

Cost of Entire Job	*Total*	*Per Pc. Fin.*
Base run cost (as above)	$612.00	.644
Restrikes	41.00	.043
Total	$653.00	.687
Less: Salvage value of scrap	4.00	.004
Net cost of order	$649.00	.683

EXHIBIT A

950 good pieces finally produced. The lower right hand portion of the exhibit shows the net cost of the entire job, after crediting the salvage value of the scrap from 50 spoiled pieces; this is arranged so as to indicate what the total cost would have been if all the pieces had been good at the first operation, what it was after absorbing the cost of re-strikes, and what it was after crediting the salvage value of the scrap.

The lower left hand section of the exhibit is a separate computation of the cost of defective work, including both the re-strike cost and the net loss on the spoiled pieces. This supplies the significant fact that on this order each piece finished cost 7½ cents more than it would have cost had the order been completed perfectly at the first run.

Values of by-products enter into this illustration only in respect to the salvage obtained from the scrap material. More attention is given to the assignment of costs incurred as between the major operation and the secondary operations than is usually the case. It should be borne in mind, of course, that this is merely an illustration, intended to bring out the significant items in cost accounting for spoilage. Varying conditions in manufacturing plants of different kinds will call for varying methods, and the procedure naturally will be modified extensively where a standard cost system is in use and actual costs are not accumulated on individual orders.

Accounting for Scrap

The accounting problem in connection with scrap is much simpler. The production of certain scrap materials is a normal and essential feature of operations in wood-working, metal-working, and many other industries. Ordinarily the amount is dependent on product design, type of raw material used, and operating practice, and there is no particular point in attempting to measure the cost repeatedly except as a variance from a standard or allowed cost.

Is is essential, however, to reflect in the accounts the values recovered or recoverable, partly for the purpose of arriving at the proper net cost of the finished major product, and partly to insure control over the scrap inventory, to prevent waste and pilferage. The common practice of treating scrap sales as miscellaneous income, to be credited directly to the profit and loss account, is unsatisfactory in both respects.

An acceptable procedure is to place a value on the scrap recovered—either the gross salable value, if little expense is involved in handling and selling the product, or the net value in the production department after due allowance for expenses of reclamation, storage, and sale. This amount, properly calculated, should be credited either to the cost of raw materials, or (if that is not practical) to the overhead expense of the department in which the scrap is produced.

The simple illustration in Exhibit B indicates the type of calculation which may be useful in determining the proper net raw material cost chargeable to the finished product in the case of a wood-working plant where cutting operations result in the salvage of three types of items: (1) usable lumber, in small sizes, which may

EXAMPLE OF COST ADJUSTMENT FOR SCRAP VALUE IN FURNITURE FACTORY

Total value of new lumber drawn from stock for production during period..		$14,310.20
Value of materials recovered:		
Usable lumber returned to stock (at market cost).....	$1,027.18	
Scrap pieces salable for kindling, etc. (at sale value).....	88.60	
Sawdust	27.20	
		1,142.98
Net cost of lumber used in production (91.8% of total value new).....		$13,167.22

(For standard material charge on new lumber use 91.8% of cost; other inventory credits to come from scrap credits; variances may be checked to determine percentage scrap recovery value.)

EXHIBIT B

be returned to stock and re-issued for the production of other articles; (2) scrap lumber, not usable in production, but salable for kindling or otherwise; (3) sawdust, salable or usable as fuel in the plant.

When tests have been run on the net material usage in the production of various articles, it should be possible to establish standard costs and to make periodic inventory adjustments in accordance with the standard cost calculations. Separate inventory accounts may be created for the scrap expected to be produced, and may be credited with actual sales or further usage of these scrap-recovery items. Periodic physical inventories will determine whether or not the standards are being met in practice.[4]

Accounting for By-Products—Flour Milling

Typical accounting for by-products differs from the procedure outlined above in that the by-products usually are of substantial value, and require further processing after their separation from the major product. In these cases a careful analysis is necessary to determine (a) what quantity of by-products will be recovered, (b) what price they may be expected to bring when their processing has been completed, and (c) what expenses will be incurred in the processing. From the above facts a calculation can be made to indicate the estimated net value of the by-products, and this will be credited against the cost of the major product.

Exhibit C presents an illustration of the method as applied to a rather simple problem of this type This example is taken from

EXAMPLE OF COST TEST ON MANUFACTURE OF FLOUR*

Cost of wheat per bu., 85¢	
Cost of wheat per bbl. of flour (estimated 4.6 bu. to make 1 bbl.)	$3.91
Less: Credit for mill feed (estimated 72 lbs. @ $18.00 per ton—see note)	.65
Net material cost per bbl. of 100% flour	$3.26
Add: Allowance for expenses of milling, selling, and administration	1.00
Net sold cost per bbl.—basis in bulk at mill (subject to addition of cost of packages, transportation, etc.)	$4.26

NOTE—Net value of mill feed calculated as follows: current selling price of feed, $20.00 per ton; allowance for handling, shipping, and selling expense, including safety factor, $2.00 per ton; net by-product value, $18.00 per ton.

* Cost form and illustrative figures supplied by Mr. A. L. Chandler of the Millers' National Federation.

EXHIBIT C

[4] For another treatment of scrap loss see Kingsbury "Manufacturing Budgets and Standards" (N. A. C. A. Yearbook, 1929).

the wheat milling industry, in which the major product is flour and the by-product is mill feed. The cost of the flour is computed by taking the cost of wheat, adding the expenses of processing, and deducting the estimated realizable value of the mill feed recovered in the milling process.

The value assigned to the mill feed normally would be the amount for which it can be sold, less the expenses of selling, handling, shipping, and delivery. Since these amounts are variable, and since the market price of the feed may change before a sale is made, the amount to be credited can be arrived at only in an approximate way. This being the case, the management in this and other similar industries ordinarily strives for a conservative by-product credit, to prevent over-valuation of the by-products and consequent under-estimate of the costs applicable to the major product. Thus an arbitrary "safety factor" sometimes is introduced into the calculations of the by-product value, to provide against fluctuations in market price and unexpectedly heavy distribution expenses.

The accounting treatment of by-product credits may have an important influence on managerial policy and must be in accord with the needs of the management. Sometimes this involves a complete reversal of the ordinary accounting procedure, as in the following example.

Manufacture of Linseed Oil and Meal

A milling company required a quantity of linseed meal for mixing with its mill feeds. To produce this the company purchased flaxseed, which was ground, producing as a major product linseed meal and as a by-product linseed oil. At the outset the net current value of the oil was credited to the process, and the residual cost was charged against the linseed meal. Under this procedure the calculated cost of the linseed meal fluctuated with changes in the value of the oil, whereas the market price of linseed meal purchased indepedently did not necessarily fluctuate in a similar manner.

After some consideration the company reversed its accounting procedure, treating the meal as a by-product and the oil as the major product. The current market cost of the meal was credited to the process (and charged to the mill feed department), and the

remainder of the seed cost and processing expense was charged against the oil recovered. This resulted in a separate profit and loss account for linseed oil. At any time when the charges thus allocated against the oil could not be recovered through available selling prices, the oil mill was closed down and linseed meal was purchased from outside sources.

By-Products—Beef Packing

Exhibit D presents a somewhat more complicated case of the same sort. This illustration shows how cost figuring is done in the cattle division of the meat packing industry. The raw material purchased is the live animal; the major product is dressed beef; by-products consist of hides, edible fats, and a variety of other edible and inedible items.

Under the usual cost accounting practice followed by the industry the cost sheet on a "test lot" shows first the total amount paid for the live cattle, and second an allowance for the expenses normally incurred in the slaughtering and dressing process and in the chilling and temporary storage of the dressed beef. The expense figures used are based on previous average experience, pos-

EXAMPLE OF CALCULATION OF BEEF COST IN A MEAT PACKING PLANT

No. head, 30. Total live weight, 33,360 lbs. Avg. live weight, 1,112 lbs.
Grade, good steers. Bought from Q. Co. Date, 3/27/34.

Live Basis	*Weight, Lbs.*	*Total Cost*	*Cost per Cwt. Alive*
Live cattle cost	33,360	$2,135.04	$6.40
Expenses:			
Killing and dressing (@ $2.15 per head)		64.50	.19
Cooler (@ 29¢ per cwt. dressed)		56.30	.17
Total cost and expense		$2,255.84	$6.76
By-product credits:			
Hides	2,160	$ 121.15	$ .36
Fats	1,230	42.62	.13
Other items	2,146	90.35	.27
Total credits	5,536	$ 254.12	$ .76
Net cost		$2,001.72	$6.00

Dressed Basis		*Cost per Cwt. Dsd.*	*Yield*
Cost per cwt. dressed	19,415	$ 10.31	58.2%
Allowance for cooler trim, etc.	155	.08	.5
Total cost of saleable beef	19,260	$ 10.39	57.7%

EXHIBIT D

CALCULATION OF BEEF BY-PRODUCT CREDITS

Hides	*No.*	*Green Wt., Lbs.*	*Cured. Wt., Lbs.*	*Price per Cwt.*	*Value*
Heavy hides	20	1,456	1,194	$8.25	$ 98.51
Heavy hides, branded	5	364	298	6.75	20.12
Light hides	5	340	279	7.25	20.23
	30	2,160	1,771		$138.86
Expense (1,771 lbs. cured weight @ $1.00 per cwt)					17.71
Net value of hides on killing floor					$121.15
Fats					
Total fats (820 lbs. caul and ruffle fat plus estimated 410 lbs. addl. killing fats = 1,230 lbs. total weight of raw fats)					
Estimated yields:					
Oleo oil @ 70% of raw fats			861	$5.75	$ 49.51
Tallow @ 10% of raw fats			123	4.00	4.92
			984		$ 54.43
Expense (984 lbs. rendered weight @ $1.20 per cwt.)					11.81
Net value of fats on killing floors					$ 42.62
Miscellaneous By-Products					
Edible items:					
Tongues			228	$11.00	$ 25.08
Livers			326	12.50	40.75
Hearts			116	4.00	4.64
Tails			34	10.00	3.40
Sweetbreads			14	16.00	2.24
Brains			25	5.00	1.25
Head and cheek meat			161	3.00	4.83
			904		$ 82.19
Expense (904 lbs. @ $1.00 per cwt.)					9.04
Net value of edible items					$ 73.15
Inedible items:					
Bones, horns and hoofs			445	$ 3.00	$ 13.35
Grease			183	2.50	4.58
Tankage			614	1.50	9.21
			1,242		$ 27.14
Expense (1,242 lbs @ 80¢ per cwt.)					9.94
Net value of inedible items					$ 17.20
Total miscellaneous by-products					$ 90.35

EXHIBIT D 1

sibly with some adjustment for any differences in current wage rates, volume of production, or other factors.

By-product credits are arrived at as illustrated in Exhibit D-1. It will be noted that some of the figures may be taken from actual weight or measurement of the by-products actually produced from this particular lot, while other figures are estimated on the basis of normal experience.

For example, the so-called "green weight" of hides may be determined by actual weighing as the hides leave the killing floor, but the cured weight which will finally be available for sale must be estimated on the basis of past experience. Similarly, some fats can be weighed at the time of the slaughtering operation, while others are recovered at such other times and places that it may not be practical to take their actual weights, an estimate being necessary. The amount of yield of edible and inedible oils also must be estimated, and of course the expenses to be incurred are entirely matters of estimate.

When the calculation has been completed the net value of all the by-product items will be combined into one total and deducted from the aggregate expenditure previously recorded. The resultant net cost will be allocated to the major product, the dressed beef. A further calculation is necessary to convert the cost per cwt. alive into a cost per cwt. dressed, with due allowance being made for the initial yield of dressed beef and for subsequent losses which may take place due to shrinkage, trimming in the coolers, etc. This cost ultimately will be measured against the selling value of the dressed beef, to determine the profit or loss on the operation.

Under this procedure the profit or loss should show up solely in the account for sales of dressed beef, since the by-products have been set up on the books at a theoretical net recoverable value. As a matter of fact, the procedure does not lead to elimination of all profit or loss on the by-products, since many of the computations are estimates and the actual experience often is somewhat different. For example, the net amount of each by-product recovered may be somewhat more or less than was estimated, the price at which it is finally sold may be above or below the price used in the cost calculation, and the expense of processing may be greater or less than was anticipated. Thus the by-product accounts typically do contribute some additional profit or loss to the amount figured on the major product.

Costs and Selling Price

Perhaps the most striking thing about the cost accounting for cattle operations is the way in which the information is used as a guide to management in a meat packing establishment. Under orthodox cost accounting theory it might be supposed that the

packer, having determined the cost of his dressed beef according to the formula indicated, would go into the market with a definite policy of not selling that beef except at cost plus the amount necessary to provide for distribution and administrative expenses plus a reasonable profit.

Unfortunately for theory, meat cannot be sold in this way. The product is highly perishable, and must be moved quickly into consumption. Large quantities of meat are constantly being offered in the open market, and more is continuously on the way and soon to be available. In these circumstances the packer must sell his product for what it will bring—which is to say that he is immediately and definitely governed by the conditions of supply and demand. The consuming public will pay only a certain amount for the total of meat which is to be sold, and that is the only amount that the packer can obtain for his product.

In this situation he consciously and definitely uses his cost figures as all cost figures probably ought to be used—that is, he works backward from the available selling price to the raw material cost which he can afford to incur. In other words, he determines what he can pay for cattle in the light of what he can obtain currently for beef and for the various cattle by-products. An extended discussion of this subject would be impossible within the scope of a paper of this type, but the fundamental principle involved is worthy of careful note.[5]

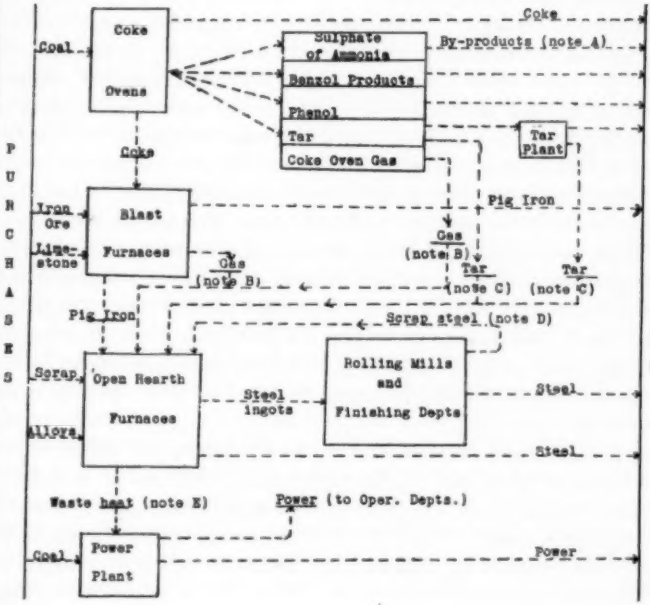
By-Products in Steel Manufacturing

Another example of by-product cost accounting is furnished by the steel industry. The manufacture of steel involves a number of successive processes in each of which there is a major product and one or more by-products. A distinguishing feature with respect to the by-products is the recovery of a number of substances which are not sold as such, but are used wholly or partly in other manufacturing processes.

Exhibit E shows by means of a diagram the principal processes and some of the more important products and by-products recovered. The major line of processing proceeds through the manufac-

[5] Further explanation of the principle involved is given in *Packinghouse Accounting* by the Committee on Accounting of the Institute of American Meat Packers (University of Chicago Press).

ILLUSTRATION OF ACCOUNTING FOR BY-PRODUCTS IN A STEEL MILL*



NOTES

A - Coke oven by-products credited to cost of coke at average sales price per unit for the month.

B - Coke oven and blast furnace gas credited respectively to cost of coke and cost of pig iron at computed value based on cost of fuel oil yielding equivalent heat units.

C - Tar and pitch used as fuel credited to cost of coke at computed value based on cost of fuel oil yielding equivalent heat units.

D - Scrap steel re-melted credited to cost of finished steel at market cost of equivalent grades purchased.

E - Waste heat from furnaces used to generate steam credited to steel ingot cost at computed value based on cost of coal yielding equivalent heat units.

* Reproduced through courtesy of E. D. Cayia, Chicago.

EXHIBIT E

ture of coke, the production of pig iron in blast furnaces, and the production of steel ingots in open hearth furnaces, to the rolling of ingots into rails, bars, sheets, and structural shapes.

Some of the most important by-products are recovered in the manufacture of coke, and the typical large steel plant has a rather extensive processing department devoted to the recovery and further processing of these by-products (sulphate of ammonia, benzol, phenol, tar, etc.). Many of these by-products are sold. On the other hand, blast furnace gas, coke oven gas, and some of the tar derivatives may be mixed and used for heating in the open hearth furnaces; waste heat from the open hearths is used in the generation of steam, which is converted into power for use by the various operating departments; scrap metal recovered in the various processes is re-melted to produce new steel ingots, etc.

The footnotes to Exhibit E explain the accounting methods used by one large steel company in recording the value and disposition of these by-products. It will be noted that in some instances values are those recoverable on sale of the products, while in some instances they are the equivalent costs of similar products if purchased independently for use in the several manufacturing processes.

Practically all genuine by-product accounting is carried on according to the procedure illustrated in Exhibits C, D, and E, or some adaptation of that procedure. The method of arriving at the by-product values may differ according to the characteristics of the markets for such by-products, but the main objective in every instance is the determination of the cost of the major product, which is arrived at by deducting from total costs the net residual value assigned to the by-products.

Problems of Accounting for Joint Products

A different approach is necessary in industries where a number of products are produced jointly, and there is no one which may be designated as the major product. In these industries the joint cost must be allocated to the various products according to their relative values, since it cannot be assumed that any single product is the special objective of the processing.[6]

[6] For an excellent example of a case where alternative methods are possible see Nickerson "Cost Allocation in the Manufacture of Counters and Innersoles," (N. A. C. A. Bulletin, July 1, 1933).

One of the commonest forms in which this problem presents itself is in the joint production of a group of products which fall into a variety of grades or classes, each being of a somewhat different value. If costs were allocated on a uniform basis to all such products, the realizable selling price on some would be substantially above cost and on others substantially below cost. Obviously neither inventory valuation nor statements of profits on such a basis would have any usefulness to the management, or indeed any theoretical validity.

Usually it is impossible to distinguish the costs incident to production of the various grades, at least in the initial stage of the process. It may even be that the costs incurred will have the appearance of being greater in connection with the lower grades of product than in the higher grades. For example, in the production of glue, the batches of materials are cooked and re-cooked several times, with some product obtained at each cooking; the last processings produce inferior grades of glue, which might appear to have a higher cost but which certainly could not be valued on that basis. Similarly, in the canning of fruits the top grade may require the smallest amount of work, while additional effort may be necessitated in sorting, culling, trimming, and cutting the lower grades.[7]

Obviously the cost accounting procedure must be such as to indicate whether the product recovered from each step in the process is sufficient in value to cover the cost of that step, but any accumulated allocation of costs on the basis of the several steps through which a given product passes might be wholly misleading and useless.

Joint Product Costs in Canning

The most practical method in most cases is that of combining the total cost of production of all of the grades obtained and then allocating this cost to the several grades in proportion to their relative values. This is admittedly an entirely arbitrary procedure, but with the facts what they are, any form of costing necessarily is arbitrary.

An illustration of the application of this method in a pea canning plant is given in Exhibit F. It is assumed in this instance that the

[7] For comment on this point see Bar, "Accounting for the Canning Industry," N. A. C. A. Bulletin, April 1, 1934.

EXAMPLE OF COST ALLOCATION FOR PEA CANNING PLANT*

Statement for Operations of One Month

	Total	*Per Cwt.*
Cost of peas—contract (43,000 lbs. shelled)	$1,290.00	$ 3.00
Expenses—receiving and handling:		
Receiving stations	627.10	1.46
Trucking to cannery	136.80	.32
Cost of peas at cannery	$2,053.90	$ 4.78
Expenses—canning (per can—$ .071)	2,442.40	5.68
Cost of peas in cans	$4,496.30	$10.46

Grade	*Production (No. Cans)*	*Sales Price per Can*	*Total Sales Value*	*Cost Allocated by Sell. Pr.*	*Cost per Can*
1	6,880	20¢	$1,376.00	$1,164.09	16.9¢
2	13,760	16	2,201.60	1,862.55	13.5
3	12,040	13	1,565.20	1,324.15	11.0
4	1,720	10	172.00	145.51	8.5
Total	34,400		$5,314.80	$4,496.30	

* Adapted from an illustration furnished by R. S. Willcox in Green and Willcox's *Cost Accounting Problems* (McGraw Hill).

EXHIBIT F

peas have been purchased on contract at a flat price, and that the processing operation is uniform for all grades. The peas after shelling are graded for size, and are canned in lots according to grade. From the total cost and the total estimated sales value it is possible to develop a cost per can for each grade which is proportionate to the selling price per can currently obtaining for that grade. The effect, of course, is to produce a uniform gross margin on the sales of each grade, which will be obtained as long as the selling prices remain in the same relation to one another as those used in the cost test.

Joint Product Costs in Oil Refining

The application of this method of costing in a more complex situation is shown in Exhibit G. This consists of a schedule of cost assignment in an oil refinery, where the raw material is run through a series of successive processes, each one of which produces certain products. Many of these are subjected in turn to further processing, which results in additional joint products.

The accounting for each process is set up independently, but the same method is used throughout. For example, in the straight run stills (process No 1) a charge of 10,250,000 gallons of crude oil is found to produce approximately 24% in "tops" and 75% in "tailings," with a loss of about 1%. The column headed "average net back previous year" indicates that a normal ratio of prices for

EXAMPLE OF COST ALLOCATION IN AN OIL REFINERY

(Weighted-selling-ratio method)*

Description	Gallonage *Quantity*	Gallonage *% to Total*	*Average "Net Back" Prev. Yr.*	Cost Factors *Quantity x "Net Back"*	Cost Factors *% to Total*	*Amount*	*Cost Cts. Per Gal.*
Charge:			*Process No. 1 (Straight Run Stills)*				
Crude Oil	10,250,000					$250,000.00	2.44
Process Costs						50,000.00	.49
Total Refining Cost Through Process No. 1 (average cost per gallon)						$300,000.00	2.93
Produced:							
Tops	2,500,000	24.39	9¢	$225,000.00	.4237	$127,110.00	5.08
Tailings	7,650,000	74.63	4¢	306,000.00	.5763	172,890.00	2.26
Loss	100,000	.98					
	10,250,000	100.00		$531,000.00	1.0000	$300,000.00	
Charge:			*Process No. 1-a (Asphalt Unit)*				
Trailings	500,000					$ 11,300.00	2.26
Process Costs						250.00	.05
Total Refining Cost Through Process No. 1-a (average cost per gallon)						$ 11,550.00	2.31
Produced:							
Kerosene Distillate	100,000	20.00	7.5¢	$ 7,500.00	.3228	$ 3,728.34	3.78
Gas Oil	90,000	18.00	5.0¢	4,500.00	.1937	2,237.24	2.48
Fuel Oil	225,000	45.00	3.5¢	7,875.00	.3389	3,914.30	1.74
Asphalt	84,000	16.80	4.0¢	3,360.00	.1446	1,670.12	1.98
Loss	1,000	.20					
	500,000	100.00		$ 23,235.00	1.0000	$ 11,550.00	
Charge:			*Process No. 2 (Cracking Unit)*				
Tops	2,000,000					$101,600.00	(5.08)
Fuel Oil	200,000					3,480.00	(1.74)
Trailings	2,000,000					45,200.00	(2.26)
	4,200,000					$150,280.00	3.58
Process Costs						120,000.00	2.86
Total Refining Cost Through Process No. 2 (average cost per gallon)						$270,280.00	6.44
Produced:							
Gasoline (raw)...	2,500,000	59.52	9.5 ¢	$237,500.00	.7504	$202,818.11	8.11
Kerosene (raw)...	500,000	11.90	7.75¢	38,750.00	.1224	33,082.27	6.62
Fuel Oil	1,150,000	27.38	3.5 ¢	40,250.00	.1272	34,379.62	2.99
Loss	50,000	1.20					
	4,200,000	100.00		$316,500.00	1.0000	$270,280.00	
Charge:			*Process No. 2-a (Treating)*				
Gasoline (raw)...	2,000,000					$162,200.00	8.11
Process Costs						15,000.00	.75
Total Refining Cost Through Process No. 2-a (average cost per gallon)						$177,200.00	8.86
Produced:							
Gasoline (finished)	1,995,000	99.75	10.5¢	$209,475.00	1.0000	$177,200.00	8.89
Loss	5,000	.25					
	2,000,000	100.00		$209,475.00	1.0000	$177,200.00	

* Reproduced from an article by W. B. Finlay, C.P.A., in the Pathfinder Service Bulletin, February 1936, through courtesy of the Charles R. Hadley Company, Los Angeles, California.

EXHIBIT G

tops and tailings is 9 to 4. From this it is computed that the aggregate value of the two products will be respectively about 42% and 58% of their combined total value.

When the cost of the crude oil, plus the cost of the processing, is assigned to the products on this percentage basis, the average cost per gallon is found to be $5.08 for tops and $2.26 for tailings. These assigned costs are carried through the accounting for subsequent processes For example, in the asphalt unit (process No. 1-a) the tailings used are charged in at $2.26 per gallon; in the cracking unit (process No. 2) tops are charged in at $5.08 per gallon. The same method of cost allocation is followed in each process, with a resultant assignment of cost to each joint product on the basis of its estimated percentage of the total recoverable value of all products obtained in that process.

It will be noted in this example that the costing is based on a computed market value for the various products at each stage of their manufacture. This can be done only when the products are marketable at the several stages, even though the refinery may intend to continue the processing through some subsequent stage.

This marketability of products at various stages is characteristic of many joint-cost industries. Many products of such industries have a realizable market value after any one of a number of steps in the processing. The oil refinery figures given in Exhibit G offer one example. The cotton ginning and cottonseed crushing industry supplies another; the ginning operation produces cotton fibre and cottonseed, both salable in that form, but both subject to further processing, etc. The meat industry affords another example, products being salable either fresh, cured, smoked, cooked, canned, or otherwise prepared, with a known market price prevailing at each stage of the processing. This situation, of course, facilitates cost allocation on the basis of prevailing market values.

Substitution of Actual Value for Cost

In some industries the cost problem is such that an allocation of the composite cost according to relative values is a very complicated and cumbersome process. This is particularly true where there are many individual products, differing as to nature and quality, and where there is commonly much subsequent processing with further changes in form. If, in such a case, it also happens

that the difference between the total costs and the currently obtainable net selling values is very small, the industry may adopt the practice of not attempting to allocate costs as such, but instead may substitute actual values for costs at each step in the processing.

The effect of this procedure—considered unorthodox from the viewpoint of general accounting theory as it applies in most industries—is to recognize and express in the accounts a series of profits or losses during processing, and in advance of their actual realization through sale of the final finished product. This might be unsuitable and misleading in an industry where profit margins were wide (so that the amount of profit taken up during processing would be considerable), but the departure from standard practice makes no very significant difference where the margins are narrow. This is particularly true where frequent fluctuations in price result in constantly changing values, so that repeated adjustments in values would be required in any event to insure that no costs on the books were in excess of market values.

Joint-Product Costs in Hog Packing

This is the situation in the hog division of the packing industry, which commonly employs the method of substituting values for costs at various stages of processing. An illustration of a typical cost calculation for the first processing operation is given as Exhibit H.

EXAMPLE OF HOG CUTTING TEST CALCULATIONS

No. head 30 Total live wt. 6,155 Avg. live wt. 205
Grade Good butchers Bought from J. H. Black Date 3/13/36

Value of Product	*Weight Range*	*Pct. of Live Wt.*	*Price per Lb.*	*Value per Cwt. Alive*
Hams	12/14	14.0	18.8	$ 2.63
Picnics	4/6	5.5	14.8	.81
Bellies	10/12	11.0	19.5	2.15
Plates and jowls		2.6	9.4	.24
Loins	8/10	9.2	21.5	1.98
Butts		4.0	19.5	.78
Spare ribs		1.5	14.0	.21
Trimmings		3.0	9.5	.29
Lard		16.7	10.1	1.69
Feet, tails, etc.		2.0	...	.09
Fancy meats and inedible by-products		...	...	.35
Total (finished yield)		69.5		$11.22
Killing and Cutting Expense, incl. Cond. Loss				.71
Net Value of Product after Deducting Expenses				$10.51
Cost of Hogs, Delivered at Plant				$10.63
Cutting Margin (Loss)				$ .12

EXHIBIT H

Instead of selling the entire hog carcass as one product, the packer commonly cuts it immediately into a number of products, most of which are of significant value, but none of such major importance that all the others can be designated as by-products. The pork packer, therefore, calculates daily the net value of each of those products, figured back to the cutting department by taking obtainable selling prices and deducting from them the expected costs of selling, loading, shipping, and delivery. Knowing the probable yield of each product, he can determine in this way the aggregate current value of the products which will be obtained from the average hog, and can compare this with the live cost of the hog to determine whether the killing and cutting operation will produce a profit or loss.

At the end of the accounting period, the accumulated total values of all of the fresh products are credited to the hog killing and cutting department, and the cost of the live hogs, plus the killing and cutting expenses, is charged against that department. Proper adjustment is made for inventories at the beginning and end of the period, and a calculation is made to show the "cutting margin," which then is carried into the general profit and loss account of the business for that period. Similar accounts are set up for subsequent operations, such as curing, smoking, lard refining, sausage manufacture, etc. The profit and loss statement then becomes a composite of the gains or losses resulting from the processing, instead of solely from the sale of the pork products.

Since the margin on pork operations ordinarily is very small, and since the turnover is rapid, the effect of this accounting procedure over the period of a year usually does not differ in any important degree from the effect which would result from a cost allocation of the type which was illustrated in Exhibits F and G. Any packing company which has reason to believe that accounting procedure of this sort has led to the accumulation of any significant amount of unrealized profit in its closing inventories naturally can provide for this by the creation of a suitable reserve, if it so desires.

Relation of Cost to Selling Price

So much for the accounting procedures typical of the joint-product and major by-product industries. Aside from indications which they give of ingenious adaptation of cost finding methods to

managerial needs, do they suggest anything of importance to the underlying theories of cost accounting in general?

It is being more and more frequently suggested, both by and to cost accountants, that the influence of values on costs may well be as important as the supposed influence of costs on values. Cost accountants in the great majority of industries have adhered rather generally to the theory that the price of a product should be set by determining how much it will cost to make it and how much profit the management would like to have for doing the job. It has even been claimed, and with considerable heat, that to sell goods at anything less than cost is both foolish and morally reprehensible. One of the fundamental ideas in the whole N.R.A. program was that all prices should be set in terms of cost, and that a machinery could be created for automatically converting any increased costs into increased selling prices.

The N.R.A. experience doubtless was worth much of what it cost if it accomplished nothing more than to reveal the fallacy of this theory. In the recent discussions of most governmental spokesmen, and a great majority of practical economists, emphasis has been placed on the much more wholesome doctrine that prices should be set, not in terms of whatever costs may happen to be incurred by any given organization at any given time, but rather in terms of what the public is able and willing to pay for a reasonable quantity of any given product. The recent comprehensive and significant report of the Brookings Institution on this question of sound production and pricing policy may prove a milestone in economic progress.

An Opportunity for Cost Accountants

If cost accountants are to be of maximum service to management it behooves them to consider their task not simply as one of combining a group of expenditures, with a view to measuring an appropriate selling price, but also as one of studying obtainable selling prices and cost components, to determine what a producer can afford to pay for the raw materials, labor, and other costs which enter into those products. When competition is keen, when prices permit little profit, when it is tempting to denounce other factors in the trade as "price cutters" and "chiselers," when the manufacturer longs for some protective device which will prevent the mar-

ket from falling below what he figures to be his minimum cost, it may be more fruitful to tackle the whole cost problem with a view to finding how costs can be brought within the obtainable income, instead of struggling to raise the income above the point where products can be sold continuously in reasonable volume.

This is not to say, of course, that cost finding does not fulfill an important function in the setting of selling prices—at least in a preliminary way. The cost accountant, however, should look always at his cost and selling price figures as serving two purposes —one the appraisal of costs as an indicator of desirable selling prices, and the other the evaluation of obtainable selling prices as an indicator of what costs may be continuously and successfully recovered.

The principles on which by-product and joint-product cost accounting must be carried out give emphasis to this latter point of view. They concentrate a large share of the attention on values—values of a variety of products at a number of different stages of processing, values gross and values net, current values and normal values. All these have an influence on the theoretical determination of joint costs. They are vital in determining sound managerial policies in the joint-product industries. It is worth considering whether they are not equally significant, even if not always recognized, in other lines of industry as well.

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